Canadian Centre for Occupational Health and Safety

Centre canadien d'hygiène et de sécurité au travail

# CYANIDE Poisoning and First Aid

P88-11E

88-04706/

# CYANIDE

## Poisoning and First Aid

Jessie M Callaghan

Susan R Stock

Canadian Centre for Occupational Health and Safety

May 1988

# CYANIDE--POISONING AND FIRST AID

Each publication produced by CCOHS undergoes several stages of review. As a part of this review, representatives from government, employers, and labour are requested to comment on draft copies of CCOHS documents for technical accuracy and readability.

Although every effort is made to ensure accuracy and completeness of the information, it is understood that CCOHS makes no warranty as to the accuracy or completeness of such information and assumes no liability for any damages or loss suffered as a result of any inaccuracy or incompleteness therein.

This publication is available in both official languages.

Cette publication est disponible dans les deux langues officielles.

CCOHS NUMBER P88-11E
ISBN 0-660-12867-5
DSS CATALOGUE NUMBER CC273-2/88-11E

Published 1988

---

250 Main Street East
Hamilton Ontario
L8N 1H6
416-572-2981
FAX 416-572-2206
Telex 061-8532

# TABLE OF CONTENTS


| | | |
|---|---|---|
| | PREFACE | (ii) |
| 1. | WHAT IS CYANIDE? | 1 |
| 2. | ARE ALL CYANIDE COMPOUNDS EQUALLY POISONOUS? | 1 |
| 3. | ARE THERE ANY OTHER CHEMICALS WHICH CAN CAUSE CYANIDE POISONING? | 3 |
| 4. | HOW DOES CYANIDE ENTER THE BODY? | 3 |
| 5. | CAN THE BODY GET RID OF CYANIDE NATURALLY? | 4 |
| 6. | HOW DOES CYANIDE CAUSE POISONING? | 4 |
| 7. | WHAT ARE THE SYMPTOMS OF CYANIDE POISONING? | 5 |
| 8. | WHAT FIRST AID MEASURES SHOULD BE TAKEN FOR CYANIDE POISONING? | 6 |
| | Oxygen | 6 |
| | Amyl Nitrite | 7 |
| | Artificial Respiration | 7 |
| 9. | IS THERE SPECIFIC MEDICATION TO TREAT CYANIDE POISONING? | 8 |
| 10. | CONCLUSION | 8 |
| | FURTHER READING | 10 |

# PREFACE

Cyanide is one of the few workplace chemicals for which exposure can be immediately life threatening. Death can occur within minutes or hours following a severe untreated exposure.

This publication describes what cyanide is, how short-term exposure affects the body, the symptoms of poisoning, and what first aid measures should be taken to counteract poisoning. It will be useful for occupational health and safety committees in workplaces where cyanide is used or generated as a by-product.

## 1. WHAT IS CYANIDE?

"Cyanide" refers to a large family of chemical compounds. Each chemical in this family contains a chemical unit called the cyanide ion. The cyanide ion is responsible for cyanide poisoning.

## 2. ARE ALL CYANIDE COMPOUNDS EQUALLY POISONOUS?

No, cyanide compounds are not all equally poisonous. Members of the cyanide family have a higher or lower toxicity depending on how easily the cyanide ion is released from the rest of the chemical. In this respect, cyanide compounds can be roughly separated into three groups:

- Compounds which break down in the body very easily to release the cyanide ion. These compounds have a high cyanide toxicity. For example, in hydrogen cyanide the hydrogen is very weakly attached to the cyanide, and so the cyanide ion is very easily released. Hydrogen cyanide is the most toxic member of the cyanide family. Other highly toxic cyanides are sodium cyanide and potassium cyanide. Table 1 lists some cyanide compounds which easily release the cyanide ion and describes where they might be found in the workplace.

- Compounds which do not break down in the body as easily to release the cyanide ion. These compounds have a moderate cyanide toxicity. Examples include acrylonitrile and silver cyanide. Relatively greater exposure to these chemicals is required to cause cyanide poisoning. And after the exposure occurs, symptoms of cyanide poisoning may develop more slowly than with the high-toxicity cyanides. Table 2 lists some cyanide compounds which do not easily release the cyanide ion and describes where they might be found in the workplace.

- Compounds which do not break down in the body to release the cyanide ion. This group of compounds does not cause cyanide poisoning except under special circumstances. Examples of these compounds include methyl 2-cyanoacrylate and potassium ferricyanide. These compounds can release the cyanide ion only if they react with certain chemicals or are heated to high temperatures. Table 3 lists some cyanide compounds which do not normally release the cyanide ion and describes where they might be found in the workplace.

Table 1 - Cyanide compounds with high cyanide toxicity

| Compound | Workplace Sources |
|---|---|
| Calcium cyanamide | Used in the manufacture of fertilizers, nitrogen products, pesticides and for case hardening iron and steel. |
| Calcium cyanide | Used as a fumigant and pesticide. |
| Cyanogen | Used as a fumigant and rocket propellant, and for welding and cutting metals; a by-product of blast furnaces. |
| Hydrogen cyanide (hydrocyanic acid) | Used as a fumigant and chemical reagent, for dehairing hides, electroplating, and extracting gold or silver from ore, and in the manufacture of plastics; produced from burning of synthetic materials (for example, some of those used in construction materials and furnishings) and from incomplete combustion in blast furnaces and coke ovens; a by-product in gas works. |
| Potassium cyanide | Used as a chemical reagent and for extracting gold or silver from ore, case hardening, electroplating, and photographic film processing. |
| Sodium cyanide | The same as potassium cyanide. |

Table 2 - Cyanide compounds with moderate cyanide toxicity

| Compound | Workplace Sources |
|---|---|
| Acetonitrile | Used as a solvent and to separate fatty acids from vegetable oils. |
| Acrylonitrile | Used as a grain fumigant and in the manufacture of acrylic fibers, rubber, plastics, surface coatings and adhesives. |
| Cupric cyanide | Used for electroplating. |
| Cuprous cyanide | Used as an insecticide and catalyst, for electroplating and in antifouling paints. |
| Cyanogen bromide | Used as a fumigant and pesticide and for gold extraction. |
| Cyanogen chloride | Used as tear gas and as a warning agent in fumigants. |
| Isobutyronitrile | Used as a gasoline additive. |
| Gold cyanide | Used for electroplating. |
| Malononitrile | Used as a lubricating oil additive and in the manufacture of acrylic fibers and dyes. |
| Propionitrile | Used as a solvent and dielectric fluid. |
| Silver cyanide | Used for electroplating. |

Table 3 - Cyanide compounds which can react or decompose to release the cyanide ion

| Compound | Workplace Sources |
|---|---|
| Methyl 2-cyanoacrylate | Used as an adhesive. |
| Potassium ferricyanide | Used as a chemical reagent and etching liquid, for tempering steel and electroplating, and in the manufacture of pigments, fertilizers, and blueprint paper. |
| Potassium ferrocyanide | Used as a chemical reagent for tempering steels, process engraving, and lithography and in the manufacture of dry colours, dyes and explosives. |
| Dicyandiamide | Used as an accelerator, stabilizer and catalyst, for case-hardening, and in the manufacture of fertilizers, dyestuffs, explosives, fire-proofing, cleaning, and soldering compounds. |

## 3. ARE THERE ANY OTHER CHEMICALS WHICH CAN CAUSE CYANIDE POISONING?

Yes, any chemical compound which contains carbon and nitrogen could, under very specific conditions, produce the cyanide ion. Examples of these compounds include toluene diisocyanate and sodium thiocyanate. If these compounds are heated to very high temperatures or burn, they could decompose (break down) and form hydrogen cyanide.

Whether or not hydrogen cyanide is given off during a fire depends on the amount of oxygen available to support the fire, the rate of burning and several other factors. Table 4 lists some chemicals which may decompose to release hydrogen cyanide and describes where these chemicals might be found in the workplace.

## 4. HOW DOES CYANIDE ENTER THE BODY?

Cyanide compounds can enter the body by inhalation, absorption through the skin or eyes, and ingestion (swallowing). They are often very rapidly absorbed into the body.

Table 4 - Some related compounds which can decompose to release the cyanide ion

| Compound | Workplace Sources |
|---|---|
| Potassium cyanate | Used as a herbicide and in the manufacture of pharmaceuticals. |
| Sodium cyanate | Used in the manufacture of pharmaceuticals and for case-hardening. |
| Sodium thiocyanate | Used as a solvent and medicine, in dyeing and printing textiles and in black nickel plating. |
| Toluene diisocyanate | Used in the manufacture of polyurethanes, elastomers and coatings. |

## 5. CAN THE BODY GET RID OF CYANIDE NATURALLY?

Yes, the body can detoxify and eliminate small amounts of cyanide. This is because the cyanide ion combines with chemicals normally found in the body to form less harmful chemicals. For example, small amounts of thiosulfate are found in the body and can combine with the cyanide ion to form the less harmful chemical thiocyanate. This chemical is then passed out of the body in the urine. As well, the cyanide ion can combine with a vitamin in the body called hydroxycobalamin. This combination forms non-toxic vitamin B12.

Small amounts of hydrogen cyanide can be exhaled through the lungs.

A small amount of cyanide can be present in the body without causing any symptoms. For example, no symptoms are expected if the blood cyanide level is 0.2 parts per million. After an exposure, cyanide levels in the body usually return to normal within four to eight hours. Only if the body defense systems are overcome, by exposure to too much cyanide in too short a time, does poisoning result.

## 6. HOW DOES CYANIDE CAUSE POISONING?

The cyanide ion interferes with essential chemical reactions in the body. One of the most serious effects of cyanide is that it interferes with the action of certain chemicals known as enzymes, which help the cells of the body use oxygen. As a result, the cells cannot use oxygen, begin to deteriorate and may die.

When the cells of the body cannot use oxygen they switch to a type of respiration which does not use oxygen. This type of respiration produces lactic acid which can result in too much acid in the body. The lack of oxygen in cells and the build-up of lactic acid cause the symptoms of cyanide poisoning.

## 7. WHAT ARE THE SYMPTOMS OF CYANIDE POISONING?

The early symptoms of cyanide poisoning are weakness, headache, giddiness, confusion, vertigo (dizziness with a sensation that the room is spinning), anxiety, nausea and vomiting. These may be the only symptoms in a person who has been exposed to a small amount of cyanide and who is removed from the exposure immediately. With a mild exposure these symptoms may gradually disappear without any treatment.

In addition to the above symptoms, skin contact with potassium cyanide or sodium cyanide can irritate or blister the skin. Swallowing most cyanide compounds causes a bitter, burning taste in the mouth, tightness or numbness in the throat, and watering of the mouth.

In most cases of cyanide poisoning, the smell of bitter almonds is present on the breath or vomit. About 50 percent of all people are born without the ability to smell this odour. Therefore, it is not a reliable sign of cyanide poisoning.

In severe cases of cyanide poisoning, the victim's breathing may speed up and, as the situation worsens, become irregular, slow and gasping. First, the blood pressure is high and the heart rate slow. Later, the blood pressure drops and the heart rate becomes fast. The victim may feel the heart pound and the chest tighten. The inside of the mouth is cherry red. Fluid may fill the lungs and interfere with breathing.

The lack of oxygen to the brain can lead to seizures. There may be a severe drop in blood pressure, and the blood vessels may collapse. Cyanide victims rarely look blue (cyanotic), except sometimes just before death. Rather, the skin tends to have a pink or red colour.

In severe poisonings, the victim loses consciousness and enters a coma. Breathing can stop. This is the most common cause of death from cyanide poisoning.

The speed at which toxic effects and death occur depends on the exact cyanide compound and the amount absorbed. With larger amounts, death can occur within minutes. Moderate amounts can cause death within hours. Small amounts can cause harmful effects from which the victim will recover.

A cyanide poisoning victim who starts to lose consciousness or has difficulty breathing must have specific treatment immediately to survive.

## 8. WHAT FIRST AID MEASURES SHOULD BE TAKEN FOR CYANIDE POISONING?

As soon as it is suspected that cyanide poisoning has occurred, a call should be put in for medical assistance. The emergency response team must be made aware that it is a cyanide emergency, so that the appropriate equipment and medications can be brought to the site.

If cyanide poisoning has occurred, it is essential that first aid be administered immediately. First aiders must ensure their own safety before attempting a rescue. If it is suspected that there is cyanide in the air, first aiders should wear the appropriate respiratory protection and use the "buddy" system. In general, in an emergency or for planned entry into unknown concentrations, a positive pressure, full facepiece self-contained breathing apparatus or a positive pressure, full facepiece supplied-air respirator with an auxiliary positive pressure self-contained breathing apparatus should be worn. Also, the rescuers should wear protective clothing, if there is any chance of their coming into direct contact with cyanide. This protective clothing would normally include wearing resistant gloves. The exact type of resistant materials for protective clothing varies depending upon the exact cyanide compound involved and specific advice should be obtained.

Once the safety of the rescuers is assured, the first priority is to remove the victim to fresh air away from the source of cyanide contamination, or to remove the source of contamination.

In the case of skin contact, the first aider should flush the contaminated skin for 15 to 20 minutes with lukewarm, gently flowing water. Contaminated clothing should be removed while the victim's skin is being rinsed clean.

In the case of eye contact, the first aider should flush the contaminated eye for 15 to 20 minutes with lukewarm, gently flowing water. The victim's eyelid should be held open to ensure complete rinsing. Care should be taken not to rinse contaminated water into the unaffected eye.

If the cyanide has been swallowed, vomiting should not be induced. Instead the victim should rinse his/her mouth and drink 8-10 ounces (250-300 ml) of water. Nothing should be given by mouth if the victim is losing consciousness or is unconscious or convulsing. This is because there is an increased chance the vomit will be inhaled if the victim becomes drowsy or comatose.

The rest of the advice in this section is appropriate for exposure to cyanide by any route.

### Oxygen

If oxygen, preferably 100% oxygen, is available in the workplace, it should be given, by a person trained in its use, to anyone suspected of having cyanide poisoning. Oxygen is effective in cyanide poisoning because

it may reverse the attachment of cyanide to the enzyme which helps the body cells use oxygen. In that way it may lessen some of the toxic effects of cyanide. It also appears to speed up the conversion of the cyanide ion to thiocyanate. In addition, oxygen has been shown to improve the action of drugs that reverse cyanide poisoning.

For victims of cyanide poisoning with relatively mild symptoms such as anxiety, dizziness, and nausea, the only first aid needed may be removal from the source of contamination and the administration of 100% oxygen. However, if the victim's condition does not improve immediately, other measures are needed.

## Amyl Nitrite

If the victim has difficulty breathing, becomes more confused, or starts to lose consciousness, a trained person should give the victim amyl nitrite. This antidote comes in capsules or "pearls" that can be crushed and inhaled. A pearl [0.3 milligram (mg) size] should be crushed onto a handkerchief or gauze and held to the victim's nose for 15 to 30 seconds of each minute. A new pearl should be used every 5 minutes. (Amyl nitrite pearls come in two concentrations: 0.3 mg and 0.18 mg. If 0.18 mg pearls are used, then a new pearl should be used every 3 minutes.)

When amyl nitrite is used, a trained person should check the victim's blood pressure regularly. This is because amyl nitrite could cause a serious drop in blood pressure. If the blood pressure drops below 80/60, it may be necessary to stop the amyl nitrite. The opinion of a physician should be obtained immediately. If a physician is not readily available, call the nearest Poison Control Centre.

The use of amyl nitrite should not delay getting medical assistance or transporting the victim to the hospital. The amyl nitrite should be used while awaiting medical assistance or the ambulance and can be used while transporting the victim to the emergency facility.

Amyl nitrite does not necessarily have to be kept in all workplaces where cyanide exposure may occur. The decision should be made based on the actual risk of poisoning and on the accessibility of the closest emergency medical facility which can provide the appropriate treatment. If amyl nitrite pearls are kept in work areas where cyanide compounds are used, special care must be taken in storage. The contents of a capsule can decompose over time or when kept at high temperatures. Internal pressure can build up in the capsule and cause the capsule to explode when it is opened for use. Glass splinters could then injure the victim or first aiders. To avoid such problems, it is best to store amyl nitrite at a cool temperature--preferably below 15°C (60°F). Also, the manufacturer's expiry date should be checked regularly and the amyl nitrite replaced as necessary.

## Artificial Respiration

If the victim is not breathing, artificial respiration should be given by a trained person through a special bag and mask. If the heart has stopped, cardiopulmonary resuscitation (CPR) should be given. Mouth-to-mouth respiration should not be given because cyanide may be absorbed by the rescuer

from the mouth-to-mouth contact. Amyl nitrite can be given at the same time as artificial respiration by placing it near the intake valve of the bag or mask.

A physician or the nearest Poison Control Centre should be consulted for all cases of cyanide exposure if the exposed person has any symptoms. Some of the recommendations given here, for example, the administration of amyl nitrite, may be considered medical acts in some jurisdictions. Therefore, these recommendations should be reviewed with a physician and appropriate delegation of authority obtained, if necessary.

## 9. IS THERE SPECIFIC MEDICATION TO TREAT CYANIDE POISONING?

Yes, there is specific medication to counteract cyanide poisoning. In Canada, this involves the combined use of two antidotes: sodium nitrite and sodium thiosulfate. These drugs must be administered by people with medical training because they are injected directly into a blood vein. Also, because of possible side effects (for example, a severe drop in blood pressure), the patient's condition must be closely monitored while the drugs are administered.

Currently, other countries use different antidotes for cyanide poisoning. In Britain, cobalt EDTA (Kelocyanor) is the preferred medical treatment; in France, hydroxycobalamin and sodium thiosulfate are the treatments of choice, and in West Germany, 4-DMAP is recommended. These drugs have not been recommended for use in Canada, either because there are serious side effects associated with their use (cobalt EDTA and 4-DMAP) or they have not been available here in an appropriate concentration (hydroxycobalamin)

In May 1987, an international meeting of poison control experts was held to discuss the advantages and disadvantages of the different antidotes used around the world. It was recommended at this meeting that the medical treatment of choice be the combined use of hydroxycobalamin and sodium thiosulfate. This combination is effective in treating cyanide poisoning and has the least harmful side effects. The hydroxycobalamin is available in an appropriate concentration in France. Currently, Health and Welfare Canada is deciding whether to make this antidote available here. If it is approved, the recommendations for the medical treatment of cyanide poisoning will change.

## 10. CONCLUSION

Every workplace where cyanide is used must have a full preventive program so that employees can work with cyanide safely. These preventive measures include educating employees about cyanide and its harmful effects, and instituting and maintaining proper control measures, as well as providing employees with proper personal protective equipment and training them in its correct use.

In addition, employees must be prepared for emergencies involving cyanide. Training must be conducted and reviewed periodically so employees are thoroughly familiar with their role in an emergency. In particular, all elements of the first aid for cyanide poisoning must be arranged in advance, and appropriate training obtained where necessary. Antidotes to cyanide poisoning do exist and can be effective if they are used correctly. But they can also be dangerous if administered by someone without the necessary knowledge and training.

Finally, discussions should be held with your local emergency medical facility. If your workplace uses cyanide, the occupational health and safety committee should consult the local emergency medical facility so they are aware that cyanide is being used in your workplace. In this way, they can be prepared to provide the necessary medical treatment for the cyanide poisoning victim.

## FURTHER READING

Anstadt, G. Cyanide antidotes in the plating shop. Plating and Surface Finishing. Vol. 73, no. 5 (1986) p. 114-115.

Beasley, R.W.R. et al. Amyl nitrile and all that. Journal of the Society of Occupational Medicine. Vol. 28, no. 4 (1978) p. 142-143.

Bismuth, C. et al. Intoxication cyanhydrique: primauté de traitement symptomatique: vingt-cinq observations. La Presse Médicale. Vol. 13, no. 41 (1984) p. 2493-2497.

Hall, A.H. et al. Clinical toxicology of cyanide. Annals of Emergency Medicine. Vol. 15, no. 9 (1986) p. 1067-1074.

Patty's industrial hygiene and toxicology. Vol. 2C, Toxicology. G.D. Clayton et al., editors. New York: Wiley & Sons, 1982. p. 4845-4900.

Lacasse, Y. L'intoxication cyanée: Ire partie. Médecin du Québec. Mai 1982. p. 125-130.

Lacasse, Y. L'intoxication cyanée: 2e partie. Médecin du Québec. Juin 1982. p. 117-120.

Lacasse, Y. L'intoxication cyanée: 3e partie. Médecin du Québec. Août 1982. p. 69-77.

Nantel, A.J. Rapport de la réunion de l'Association Européenne des Centres Anti-Poison en collaboration avec la Commission des Communautés Européenees l'"International Program on Chemical Safety" (UNEP, ILO, WHO) et le Programme National des Centres Anti-Poison des Pays-Bas, portant sur le sujet suivant : "Medical toxicology with special reference to cyanide antidotes." Québec: Centre de Toxicologie, 1987.

Poisindex: cyanide: an overview of diagnosis and treatment. Denver, Colo.: Rocky Mountain Poison Centre, 1987.

Taraschuk, I. Cyanide. Occupational Health in Ontario. Vol. 1, no. 2 (1980) p. 27-32.

Way, J.L. Cyanide intoxication and its mechanism of antagonism. Annual Review of Pharmacology and Toxicology. Vol. 24 (1984) p. 451-481.